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Wind erodibility of arid lands in the Channel Country of western Queensland, Australia: a sequel (1994-2000)

McTainsh, G.H., Australian School of Environmental Studies, Griffith University, Brisbane, Queensland, 4111, Australia.(E-mail: g.mctainsh@mailbox.gu.edu.au)
Love, B.M., Australian School of Environmental Studies, Griffith University, Brisbane, Queensland, 4111, Australia.
Leys, J.F., Centre for Natural Resources, Department of Land and Water Conservation, Gunnedah, NSW, 2380, Australia. (E-mail: jleys@dlwc.nsw.gov.au)
Strong, C., Australian School of Environmental Studies, Griffith University, Brisbane, Queensland, 4111, Australia.

Introduction

Long term records of field-measured wind erosion rates are rare worldwide (Offer and Goossens, 2001). This is a deficiency in our research knowledge, particularly given the highly episodic nature of wind erosion processes. While the more frequently available short records of erosion rates provide valuable information, they may not provide a representative picture of the environmental factors influencing wind erosion at a location. Data are presented here from a long term field measurement project in the Channel Country of western Queensland, which started in 1994 and is ongoing. The early results from this project (1994-1997) were presented at ICAR 4 (McTainsh et al., 1999). In the present paper we present a 7 year record (1994-2000) of wind erosion rates (dust flux) and examine temporal changes in the erodibility of the same 3 land types in response to: wind conditions, rainfall, vegetation, soil surface conditions and flooding.

Materials and Methods

The field site is the remote Diamantina National Park in the Channel Country of Western Queensland. The Channel Country is an extensive floodplain channel system of the inland-draining rivers of the Lake Eyre Basin. Diamantina National Park lies within an active wind erosion region (McTainsh, 1997) and contains a variety of land types within a relatively small area, which are widespread in the Australian arid zone. The three major land types selected for this study are: claypans, dunes and downs. The claypans occupy the high floodplain of the Diamantina River, which is flooded when stage heights exceed 4.5m, which occurs every second year on average (1917-2001). The dunes are source-bordering linear dunes located on the western sides of the main rivers and the downs are the expansive very gently undulating interfluve areas between the main rivers.

The passive sediment samplers used here were designed by Fryrear (1985), and modified with a rain hood. Samples were collected at three heights (0.07m, 0.5m and 2m). Shao et al (1993) found that wind vane samplers are $90^{+}/_{-}5\%$ efficient for highly aggregated sandy loam soils in SE Australia, but as most of the aeolian fines in the Channel Country soils are particulate, these samplers are unlikely to be as efficient there.

Streamwise sediment fluxes were calculated from sediment concentration/sampling height curves. The relationship between sediment concentration and height has frequently been shown to be a power function for suspended sediments (Gillette and Goodwin, 1974). Five sampler arrays have been used in past studies (Leys and McTainsh,1994) but for practical reasons in this study, the number of sampling heights were kept to three. A comparison of the dust flux curves from two arrays revealed <2% difference.

The sediment concentration and height relationship was extrapolated downwards to 0.01m, which is not as low as Nickling (1978) (0.001m), but low enough to provide a good estimate of saltation flux without any statistically-derived distortion of the loads. Dust flux (>0.5m) is the measure of wind erosion used here as it provides an estimate of the sediment lost from the immediate area. Erodibility is measured at a broad scale using the same Land type Erodibility Index (LEI) as (McTainsh et al., 1999). The LEI measures dust flux per unit of wind energy, and is calculated by dividing dust flux (F) by the mean wind speed above threshold (6m/sec) (U>t) for each measurement period.

Results and Discussion

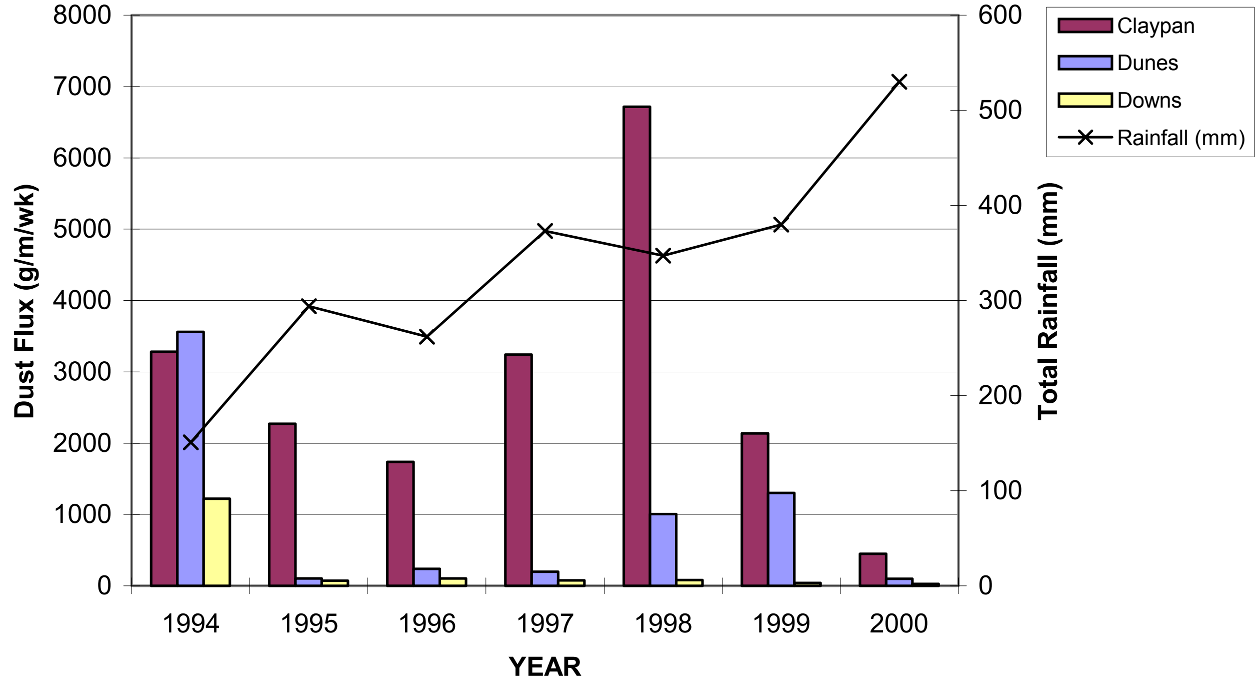
Averaging the dust fluxes for each land type for 7 years, it is apparent that the claypans are clearly eroding at the highest rate, followed by the dunes, then the downs (Table 1). This trend is the same as for the 1994-1997, however the differences between the land types have increased.

Land Type	Mean dust flux ($gm^{-1}s^{-1}$)
Claypans	0.0047
Dunes	0.0015
Downs	0.0004

Table 1: Mean dust flux (1994-2000) on 3 land types in the Channel Country.

Figure 1 shows yearly trends in dust flux on each land type in relation to rainfall. While annual rainfall shows a clear upward trend from 1994, the dust flux responses on each land type differ considerably. The dust fluxes on the downs are sensitive to rainfall; showing a clear negative relationship, whereas the claypans show a complex relationship with rainfall. The dunes show an initial decrease in dust flux, in common with the downs, then appear to track the changes in claypan dust flux as rainfall increases. The correlation between dune and claypan fluxes may be an artefact arising from the proximity of the dune site to the claypan, which resulted in some claypan dust being collected by the dune wind vane sampler.

Figure 1: Changes in dust flux on 3 land types (July to November), in relation to



rainfall.

These results indicate that the generally accepted negative relationship between wind erosion rates and rainfall from broadscale studies (Goudie, 1983, McTainsh and Leys, 1993) describes the situation on the downs and dunes land types (assuming that the artefact is real), because erosion on these land types is vegetation-limited. The negative relationship cannot, however be applied to claypans, which are rarely vegetated. Evidently, other factors are having a strong influence upon wind erosion on claypans.

The temporal trend of dust flux on the claypan in Figure 1 can be resolved into three periods: Period 1 (1994-1996) - decreasing dust fluxes, Period 2 (1997-1998) - increasing dust fluxes, and Period 3 (1999-2000) - decreasing dust fluxes.

1. Period 1 (1994-1996)

From 1994 to 1996 claypan dust fluxes decreased as annual rainfall increased. This trend appears to reflect increasing soil moisture levels.

2. Period 2 (1997-1998)

Dust fluxes increased sharply in this period. McTainsh et al (1999) attributed the 1997 increase to the supply of fresh erodible sediment as a result of the flooding of the claypan in early 1997. These high dust fluxes also occurred at low wind speeds, indicating that the erodibility of the claypan soils was unusually high. McTainsh et al (1999) quantified this erodibility change using the land type erodibility index (LEI). The further large increase in dust flux in 1998 cannot be so simply explained by prior flooding in 1998, and there was no significant decrease in annual rainfall. The increase may be due to more erosive conditions this year, but wind speed data are not yet available to support this assertion, or to perform an LEI analysis.

3. Period 3 (1999-2000)

In 1999 the dust fluxes on the claypans dropped dramatically, even though annual rainfall remained high, and there was a large flood (the second largest on record) in January, 1999 which provided another fresh load of erodible sediment. Significantly, this large flood and follow-up rains brought vegetation (for the first time in at least 10 years), which may have been sufficient to significantly reduce LEI. The absence of vegetation on the claypans up to this time had been due to hyper-salinity of the claypan soils, however the combination of a large flood and higher than average rainfall reduced the salinity levels in the topsoils (Mostert, 1999) sufficiently to allow initial vegetation growth.

In 2000 dust fluxes dropped to a long term low. Three significant floods occurred between January and March, 2000 and rainfall increased again. This combination of events resulted in a widespread coverage of vegetation on claypan, in response to reduced salinity levels in the claypan topsoils. The erodibility of the claypan therefore became vegetation-limited in period 3, in a similar way to the dunes and downs.

This positive shift in wind erosion conditions on the claypans may be a turning point in the history of the claypans in the area, and may represent the beginning of rehabilitation phase. The reason for this optimism is that the claypan vegetation has the best chance (in the past 200 years), of enduring as grazing pressure has been significantly reduced by the removal of cattle from the region in 1997, soon after the National Park was established.

Conclusions

Long term dust fluxes from claypans on the Diamantina River floodplain are more than three times higher than from dunes and downs in the same region. Wind erosion on the dunes and downs is negatively related to rainfall through vegetation cover effects, but on the claypans wind erosion is influenced by a more complex set of factors. Flooding of these high floodplains can both increase and decrease wind erosion rates. Deposition of fine sandy alluvium, which is highly erodible to wind, can significantly increase dust fluxes (as in 1997), but when major floods and high rainfalls converge (as in 1999 and 2000) dust fluxes are dramatically reduced. This convergence of events reduced the normally high salinity levels in claypan topsoils and stimulated vegetation growth, which in turn provided protection from erosive winds. 1999 may turn out to be a pivotal year in the history of claypan erosion in Diamantina National Park, as for the first time in 200 years this landscape is free from the grazing pressure of cattle. This may be the beginning of a natural claypan rehabilitation phase? A continuation of the present long term field measurement project will answer that question.

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